

# Computational Thinking Approach in Physics Experiment Based on Excel-VBA (*Visual Basic for Applications*)

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**Abstract:** This study emphasizes the importance of computational thinking skills (CTS) in physics education. The urgency of the study lies in the need to strengthen students' problem-solving abilities through the CTS approach using technologies such as Excel-VBA (Visual Basic for Applications) for scientific simulations. This study aimed to explore the use of Excel-VBA in physics learning, especially in the phenomena of stationary waves and damped harmonic oscillations. The method used was an experimental design involving students and one instructor. Data were collected through students' work in physics simulations using Excel-VBA. Data analysis was carried out by evaluating students' work in designing algorithms, performing basic programming, and verifying the results of the simulations that had been made. The results showed that students could create basic simulations of physics phenomena with Excel-VBA, which can support students' understanding of complex concepts. The simulations created include visualizations of stationary waves and damped harmonic oscillations adjusted to different variables. This study concludes that the use of Excel-VBA based on computational thinking skills can facilitate students' understanding of programming concepts and their applications in physics. This paper implies that Excel-VBA can be an interesting and practical alternative learning media to support the understanding of complex science concepts and encourage the development of basic programming skills among students.

**Keywords:** VBA (Visual Basic for Application), Microsoft Excel, Computational Thinking Skill (CTS), Learning Classroom, Science Experiment.

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## Introduction

The learning process is an activity that must be designed as well as possible to influence students to achieve the educational goals set. Education aims to motivate students to change their behavior intellectually, morally, and socially. An educator can direct the learning process to achieve goals by choosing suitable learning media. Learning media are a learning component that plays an essential role in teaching and learning activities. Media use should be a part that needs to receive the attention of educators/facilitators in any learning activity. Therefore, educators/moderators must learn to define learning media to achieve practical learning goals in the teaching and learning process (Ebner & Holzinger, 2007; Syamsiani, 2022). Learning media can act as a learning aid. Therefore, the role and

function of learning media should be considered. Because a high-quality learning process always provides rich and varied learning resources or learning media (Amalya et al., 2017; Liaw, 2008), One of the tasks of learning media is to provide experiences that cannot be directly acquired but can be presented in learning media (Karimah et al., 2014). That is why we need suitable media for every lesson. Currently, learning methods use traditional systems, especially in remote areas. This leads to educators presenting learning materials exclusively on blackboards.

Furthermore, learning occurs in only one direction, in which educators act as centers of education, and students become more passive during learning (Amin et al., 2016). Educators are expected to be able to present learning media that is interactive, engaging, memorable, and easy for

students to use. This is very important so that learning becomes more meaningful and not dull, and students can be motivated to study both in a group and independently (Amin et al., 2019; Hidayati & Wuryandari, 2012). Learning physics is complex and tedious for students to understand (Fidan & Tuncel, 2019; Gokalp, 2018). Educators can use appropriate strategies to motivate students to study physics (Grigore & Barna, 2015). Physics-informed deep learning models can improve such simulations, applicable in both forward and backward problem situations (Bekele, 2021), so that each material explained by educators is easier to understand, especially when students are actively involved in the ongoing learning process. In this case, the students get the theory and its application. Several studies have examined how simulation media are developed, how they are used in physics learning, and how practical the simulation results are. As reported by Chen et al. (2016), who developed technology in the form of video simulations, By using this simulation video, students can be encouraged to be more active and easier to understand (Shabrina & Kuswanto, 2018), so this has a positive effect on student participation and motivation (Fabregat-Sanjuan et al., 2017; Ruiz et al., 2014). Using the internet and simulations makes the teaching environment more exciting and compelling. Most physics experiments can be easily simulated by developing a spreadsheet-based simulator (e.g., MS Excel), which is inexpensive and does not require an internet connection (Katoch, 2020). Microsoft Excel is a spreadsheet application program for Microsoft Windows and Mac OS. This worksheet suite is designed to solve and answer various problems in the dynamic world of education. Microsoft Excel has many functional options for teaching issues and is superior to comparable programs (Suharyo et al., 2022). In addition, technological developments can facilitate and further develop the quality of education (Jahnke & Liebscher, 2020). All these simulation simulation programs are updated, user-friendly, and experimentally validated. This software is designed for different purposes and is limited to solving specific problems

Various studies were then conducted to examine the effectiveness of implementing VBA Excel simulation media in learning, as Perdana et al. (2019), suggest managed to show that the simulation media with VBA Excel added intellectual feasibility in the form of simple and practical learning discoveries while still being in line with current technological developments. In addition, research by Bernard et al. (Bernard et al., 2018) showed that using VBA-Excel-based learning media boosted the self-confidence of the students and thus improved their ability to understand. This can also promote student potential and stimulate easy-to-understand, exciting, and varied learning that arouses student curiosity (Putranta & Kuswanto, 2018). Rafart Serra et al. (2017) stated that teachers also gain time, effort, and workload from using Microsoft Excel spreadsheets in addition to the highlighted student benefits. The evaluation of the studies examined shows that the use of digital media in informal learning settings has an overall positive effect on informal learning, particularly on knowledge, motivation, interest, and commitment (Degner et al., 2022). Microsoft Excel can be useful for students (Perzina & Ramík, 2014). The identification of needs by educators, the choice of simulation software, and the way it is integrated into the learning environment are all essential to student learning outcomes. Educators are critical in selecting appropriate resources, sorting and compiling learning activities, and guiding students (Sarabando et al., 2014). Microsoft Excel is an excellent learning resource when implemented in the learning process-with the inclusion of Microsoft Excel, students can be trained to develop critical thinking, conceptual understanding, creativity, and collaboration skills.

Wave material is one of the learning materials that requires complete visualization (Mešić et al., 2016). Wave material is a comprehensive material, the explanation of which needs to be supported by supporting visual media. So far, learning resources for wave material are presented only as small examples of traveling waves. This has no significant impact on student understanding. Several studies also show Wave material using instructional videos but fail to encourage student engagement in learning. In addition, learning using

instructional videos or other media does not train student collaboration, so it impacts students' cognitive abilities. Some research has concluded that the teaching media presented so far have yet to make an excellent contribution to teamwork, independent learning, and understanding of the process, especially in physics lessons. This is because the learning media are formed through one-sided accounts, without student participation in training students' cognitive abilities and skills. In addition, the subject of stationary waves and simple harmonic oscillations is a physical subject that requires reasoning and accurate images in everyday life when learning the material. Educators need help explaining the mathematical and graphical aspects of this physics material. So that students tend to stick to the formula. One reason for this is the need for more learning media that are interesting, flexible, and easy to use. Learning media is the most essential part that cannot be separated from the learning process to achieve educational goals.

To enhance the efficiency of this process, it is necessary to employ suitable pedagogical techniques, among which the utilization of computational thinking skills concepts stands out as particularly effective. Computational models allow researchers to do experiments and evaluate the resulting data inside a controlled virtual setting. This enables the identification of patterns, linkages, and probable consequences within intricate systems (Granato et al., 2021; Hurt et al., 2023; Lamb & Premo, 2015). The significance of computing abilities in the contemporary period presents obstacles and possibilities during implementation. The incorporation of computational concepts into the learning process enhances students' talents, particularly in the realm of computational abilities (Hsu et al., 2018). Presently, there is a greater emphasis on the technique or strategy employed in the implementation process within computational skills (Saritepeci, 2020; Vergara et al., 2009). In computing, a crucial aspect is the procedural framework through which students engage with computational designs during their work (Lee & Hannafin, 2016; Leonard et al., 2016). When incorporating computational abilities, it is essential

to have proper preparation, including sufficient assistance from information and communication technology (ICT) systems. Wing contends that the cognitive ability to think like a computer scientist is attainable for all pupils. The emergence of this phenomenon has resulted in an expanding corpus of teacher works that explore the methods of incorporating computational thinking into K-12 education, with a particular emphasis on its integration into fundamental academic subjects (Barr & Stephenson, 2011; Sands et al., 2018; Yadav et al., 2014).

Hence, given the significance of incorporating Excel-VBA in educational settings, particularly in developing computational thinking abilities, teachers & lecturers have expressed interest in investigating this subject area. This study aims to familiarize students with Excel-VBA as a tool for instructing fundamental programming languages. It also seeks to provide Excel-VBA as an alternative approach to enhance students' thinking and comprehension of programming languages, which are often perceived as challenging, particularly within the context of physics education.

## Solutions

The methodology employs an experimental design incorporating three students and one instructor as the primary subjects for the initial trial. The data-gathering methods used in this study involve conducting interviews and analyzing student work. The objective is to develop a stationary wave simulation design utilizing Excel-VBA while including computational thinking skill methodologies.

**Table 1.** Stage of computational skill by (Lin et al., 2019)

Phase	Procedure
1	Abstraction
2	Algorithm design
3	Coding
4	Verification

The following presents the procedure for creating an Excel-VBA simulation, which is taught to students using computational thinking skills. Teknik Stationary waves are waving whose

amplitude is not fixed at the point they pass and are formed from the interference of two incident waves and a reflected wave, each of which has the same frequency and amplitude, but the phase is opposite. Stationary waves can be divided into stationary waves at the free-reflecting end and stationary waves at the fixed-reflecting end. The equation used for fixed-end stationary waves is formulated as follows:

$$Y_1 = A \sin(\omega t - kx) \tag{1}$$

$$Y_2 = -A \sin(\omega t + kx) \tag{2}$$

$$Y_s = Y_1 + Y_2 = 2A \sin kx \cos \omega t \tag{3}$$

The equation used for free-end stationary waves is formulated as follows:

$$Y_1 = A \sin(\omega t - kx) \tag{4}$$

$$Y_2 = A \sin(\omega t + kx) \tag{5}$$

$$Y_s = Y_1 + Y_2 = 2A \cos kx \sin \omega t \tag{6}$$

Next, use equations 1, 2, and 3 in a spreadsheet in Microsoft Excel. The steps for creating a stationary wave simulation at a fixed end using this equation are as follows:

1. Creates table I which contains lambda ( $\lambda$ ), wave number ( $k$ ), amplitude the angular velocity ( $\omega$ ), and time ( $t$ ). The value of the wave number ( $k$ ) filled in using a formula  $= \frac{2\pi}{\lambda}$  and for other sizes adjusted. The time ( $t$ ) act as independent variables and the others are control variables as shown in Figure 1.

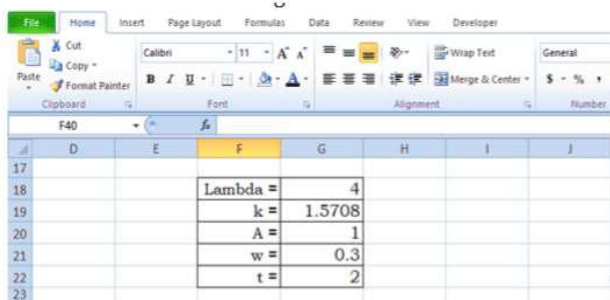


Figure 1. Entering the quantity value

2. Table II contains the  $x$  function of the values 0–9 with a difference of 0.1, the  $Y_1$  equation, the  $Y_2$

equation, and the  $Y_s$  equation as a reference in making simulation graphs.

3. Determine the  $Y_1$  function with the Excel formula  $=\$G\$20*\text{SIN}(\$G\$21*\$G\$22-\$G\$19*G28)$  and  $Y_2$  with the Excel formula  $=-\$G\$20*\text{SIN}(\$G\$21*\$G\$22+\$G \$19*G28)$  and  $Y_s$  with the Excel formula  $=H28+I28$ . Each function refers to the formula according to equations 1, 2, and 3. Function  $Y$ , which functions as the dependent variable, The calculation results can be seen in Figure 2.

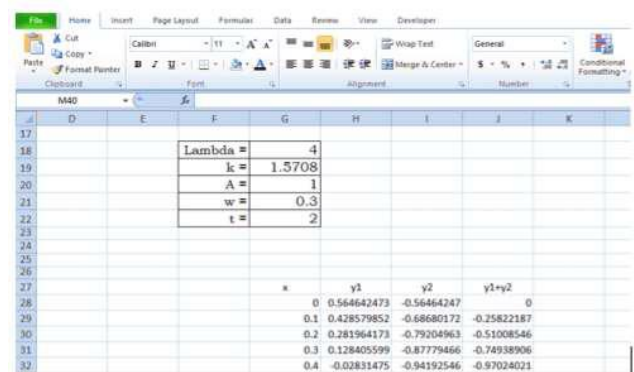


Figure 2. Calculation results for  $Y_1$ ,  $Y_2$ , and  $Y_s$  functions.

4. Function block  $Y_1$ ,  $Y_2$  and  $Y_s$  drag down along the function  $x$ , then select insert > insert charts > X Y scatter > select scatter with smooth lines > click ok, which can be seen in Figure 3.

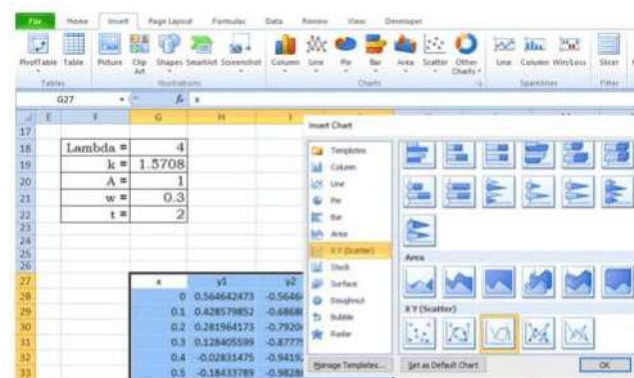


Figure 3. Creating function graphs

5. Create a control button by selecting developer > control menu > view code > VBA project > module > create code with "G22", which will be used as an independent variable. The code created is in the form of Run Stop and Reset codes, as shown in Figure 4. Then select Insert>

Illustrations > shapes or pictures; do this three times for different shapes or pictures.

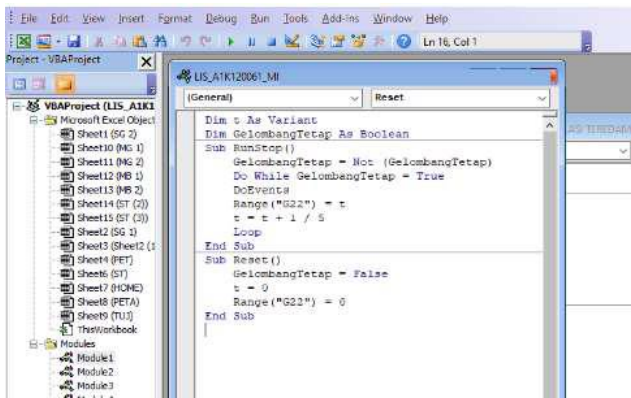


Figure 4. Making view code in fixed end stationary wave VBA

6. The way to activate the Run control button is to right-click the shape or picture > assign macro > module (Run Stop) that was created. In the same way, do the three shapes or pictures and choose the Run Stop and Reset modules, as can be seen in Figure 5.

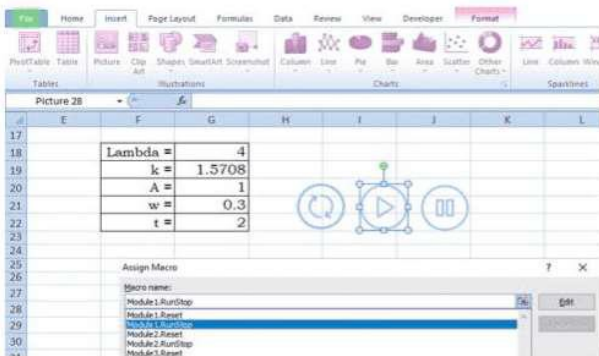


Figure 5. Activating the VBA button

The work steps for making a stationary wave simulation at the free end using equations 4, 5, and 6 are followed by work steps 1 to 6, which use the VBA view code as shown in Figure 6.

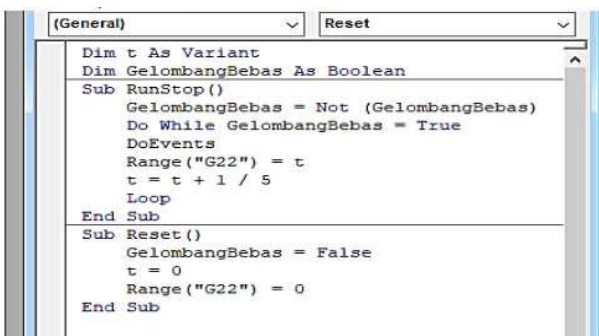


Figure 6. View code VBA on free end stationary waves

Harmonic oscillation is the motion of an object that is influenced by an inhibiting or damping force, which causes the amplitude of the oscillation to decrease slowly over time until it finally stops. The equation used can be formulated as follows:

$$x(t) = e^{-\gamma t} \left( A_1 e^{t\sqrt{\gamma^2 - \omega_0^2}} + A_2 e^{-t\sqrt{\gamma^2 - \omega_0^2}} \right) \quad (7)$$

There are three types of damping (damping) experienced by oscillating objects, namely underdamping ( $\gamma^2 < \omega_0^2$ ), Critical damped ( $\gamma^2 = \omega_0^2$ ), and overdamped ( $\gamma^2 > \omega_0^2$ ). Next, use equation 7 in a spreadsheet in Microsoft Excel. Work steps for simulating damped harmonic oscillations with underdamped characteristics using equation 7.

- a. Create table I which contains  $k, b, m, A_1, A_2, Y^2, \omega_0$  great value  $Y^2$  Fill in using Excel formulas =J13^2/(4\*J14^2) and  $\omega^2$  by using the Excel formula = J12/J14, the other quantities can be seen in Figure 7. The quantity b is the independent variable, and the others are the control variables.

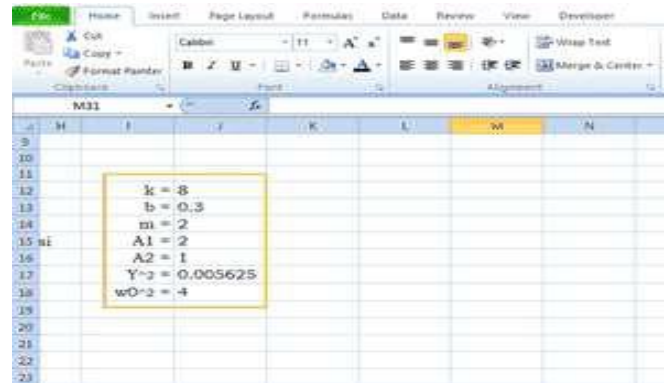


Figure 7. Quantity value input

- b. Table II contains the  $t$  function from 0-20 with a difference of 0.1, equation 7 as a reference in making simulation graphs and still paying attention to the conditions for damped harmonic oscillations with underdamped characteristics.

- c. Define function X with Excel formula = EXP (-(\$J\$13/(2\*\$J\$14)) \*E21) > =(\$J\$15+\$J\$16) \*K21\*SIN (((\$J\$18-\$J\$17) \*E21+(1/2\*3.14)) which refers to the formula according to equation 4 – function X, which functions as the dependent

variable. The calculation results can be seen in Figure 8.

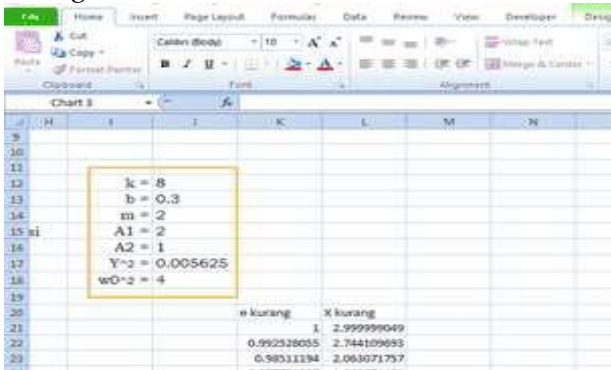


Figure 8. Calculation results of the X function

- d. Block the X function and drag it down along the X function, then select insert > insert charts > X Y scatter > select scatter with smooth lines > click ok, which can be seen in Figure 9.

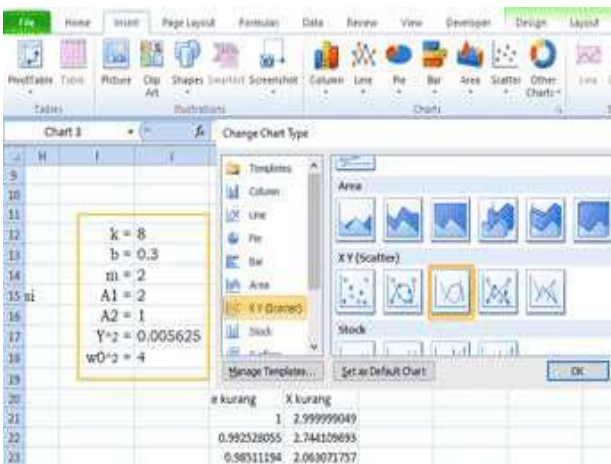


Figure 9. Creating function graphs

- e. Create a control button by selecting developer > control menu > view code > VBA project > module > Create code with "J13," which will be used as an independent variable. The code produced is in the form of Run Stop and Reset code, as shown in Figure 10. Next, select Insert> Illustrations > Shapes or Pictures. Do this three times for different shapes or pictures.

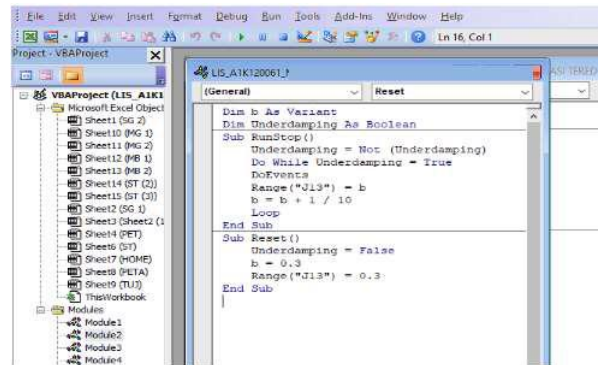


Figure 10. Making view code in VBA underdamped

- f. The way to activate the Ru control button is to right-click the shape/picture > assign macro > module (Run Stop) that was created. In the same way, do the 3 shapes/pictures and choose the Run Stop module and the Reset module, as can be seen in Figure 11.

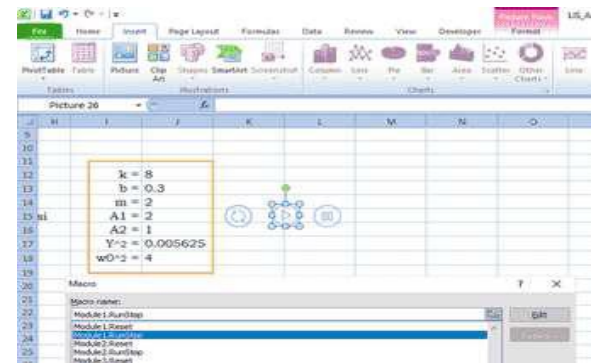
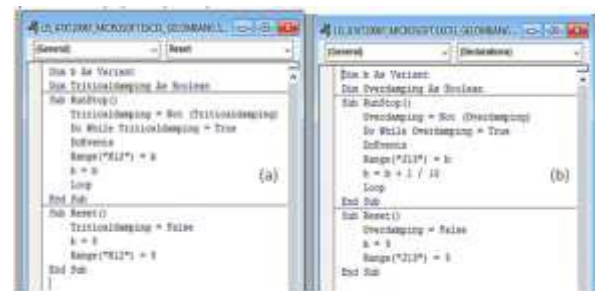


Figure 11. Activating the VBA button

- g. Repeating steps 1 to 6 for simulating damped harmonic oscillations with critical damping and overdamping characteristics using the same equation, namely equation 7, while still paying attention to the conditions for these characteristics to occur. The VBA view code used can be adjusted to the physical quantity data that has been created.



(a) (b)

Figure 12. View code in VBA (a) Critical damped; and (b) Overdamped

## Results and Discussion

The initial study resulted in a learning media product using the Microsoft Excel program and VBA in Microsoft Excel to visualize stationary wave material and damped harmonic oscillations. This learning media can be used by educators, including in explaining the material, so that it can achieve learning objectives. This media can also be used directly by students in the learning process. Educators can explain how to use the media to students. In general, this learning media is packaged as teaching materials, containing a cover page, a main menu, instructions for using the press, learning objectives, materials and simulations, and evaluations designed like a book's appearance.



Figure 13. Display of learning material made in the form of an e-module prototype

a. Data collected. This includes measurements of vibration time, wavelength, and wave frequency. After the experimental data has been collected in Excel, the next step is to analyze the data using Excel VBA. Abstraction in this stage involves creating a VBA script that can calculate important parameters such as wave speed, amplitude, and wave energy based on the data that has been collected. Students can use appropriate mathematical calculations to run VBA scripts and produce more in-depth analysis results. Students need to create a VBA script that will be used to process experimental data. This can include calculating wave speed, frequency, amplitude, or other parameters based on the input data. The abstraction stage is presented as equations (1-6) in Figure 1. After the data has been extracted and analyzed using a VBA script, the next step is to create a visualization. This can include creating graphs, charts, or tables showing wave characteristics

- b. Design algorithm. Algorithm design in computational thinking is the process of designing a logical and structured sequence of instructions to solve a problem or task systematically and efficiently. An algorithm is a series of steps or procedures to solve a task or problem. In computational thinking, algorithm design involves structured and logical thinking to find the best solution to a problem. This involves choosing the right algorithm and deeply understanding the programming language used. In this section, students package the design algorithm in the form of a pattern, as presented in Figures 2, 7, 8, and 9.
- c. Coding Stage. At this stage, the coding is packaged in the Excel-VBA programming language by looking at the wave variable as a function of time. It is made in graphical form based on equations (1-6). The results of student coding are presented in Figure 14.

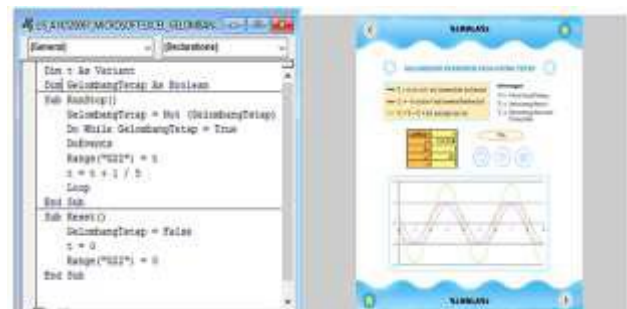


Figure 14. Simulation page in the developed e-module prototype

The form of a simulation of a fixed-ended stationary wave using Equation 1, Equation 2, and Equation 3 in Microsoft Excel is shown in Figure 15. The wave propagating to the right (in blue) is an incoming wave formed from Equation 1. The wave propagating to the left (red) is the reflected wave formed from Equation 2. Conversely, the green wave is a fixed-ended stationary wave, following Equation 3.

- d. Verification stage. This stage is concerned with verifying the results related to the simulation carried out by students to determine whether they are by the concept or theory. At this stage, students confirm their compatibility with the ideas and concepts that have been around so far, for example, between the graphs of the SIN function and the Cos function in the wave deviation equation. The results of the wave

verification carried out by students are presented in the following Figure.

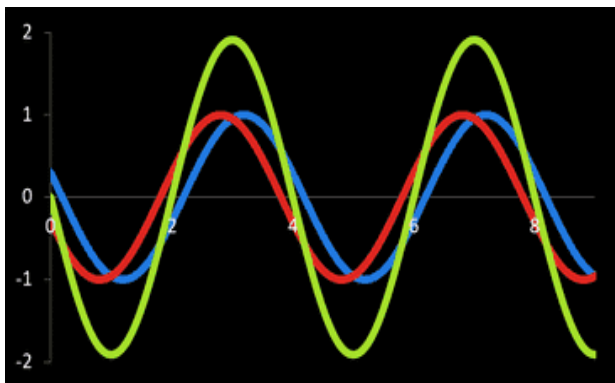


Figure 15. Stationary wave student work at fixed ends

Free-end stationary waves were performed by varying the time ( $t$ ) with three treatments, with the wave results looking like Figure 16.

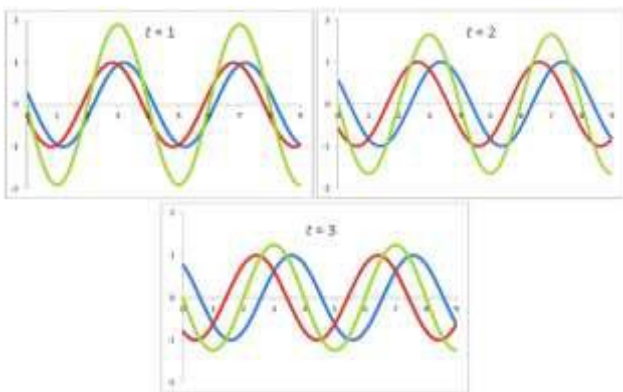


Figure 16. The work of Stationary wave students at fixed ends by varying time ( $t$ )

Next, the angular velocity must be varied  $\omega$  which was performed with 3 treatments with the wave results looking like Figure 17

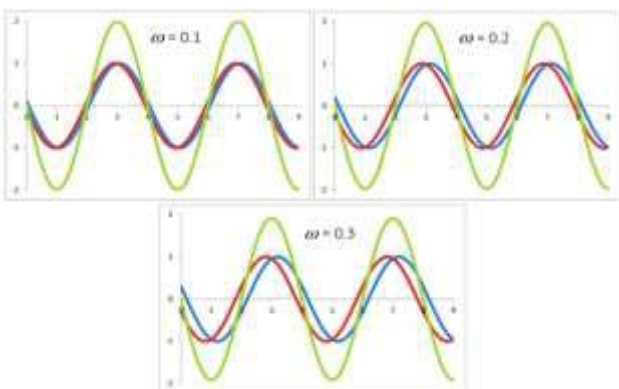


Figure 17. Student work on stationary waves at fixed end varying angular velocity ( $\omega$ )

Likewise, by varying the lambda ( $\lambda$ ) performed with three treatments, the wave results looked like Figure 18.

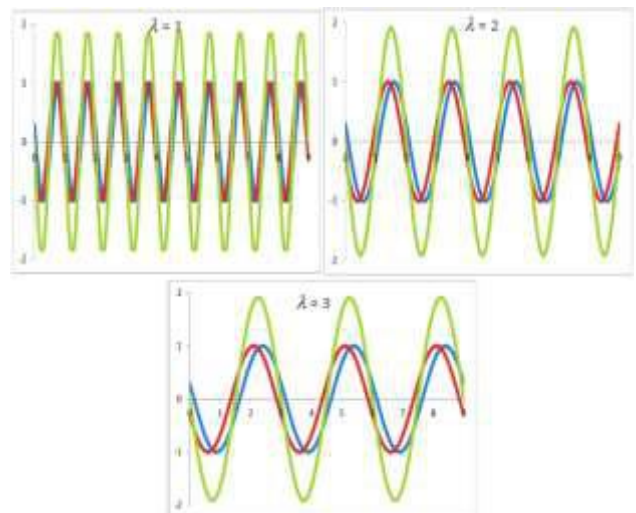


Figure 18. Stationary wave student work at Fixed End varying lambda ( $\lambda$ )

Free-ended stationary waves formed in Microsoft Excel based on Equation 4, Equation 5, and Equation 6 are shown in Figure 19. Waves propagating to the right, specifically in blue, are incoming waves formed from Equation 4, while waves propagating to the left, specifically in red, are the reflected waves created from Equation 5. The green wave is a free-ended stationary wave formed from Equation 6, the combined result of Equations 4 and 5.

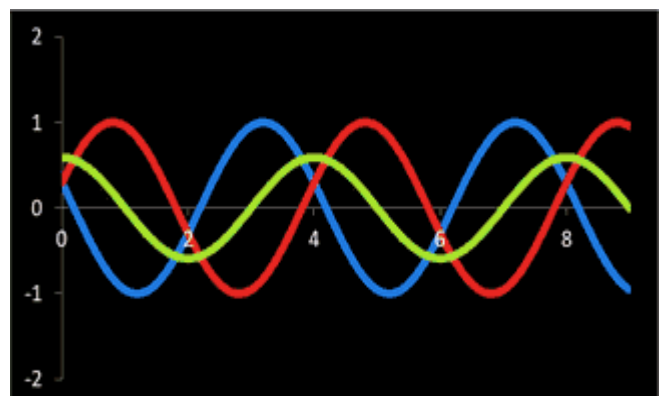


Figure 19. Student's work on Stationary Waves at Fixed Ends of Stationary Waves at Free Ends

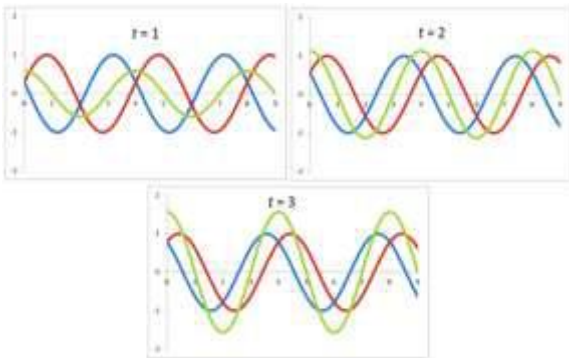


Figure 20. Student work on Stationary Waves at Fixed Ends Varying Time (t)

Furthermore, by varying the angular velocity ( $\omega$ ) with three treatments, the wave results looked like those in Figure 21.

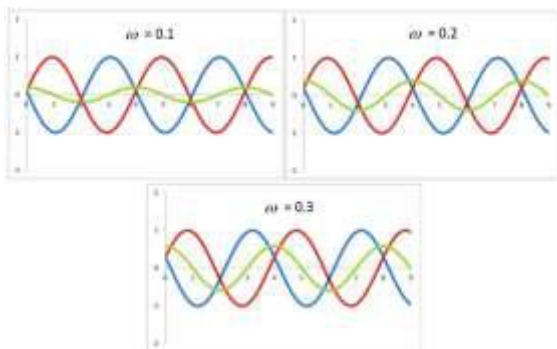


Figure 21. Student work on Stationary Waves at Fixed Ends Varying angular velocity ( $\omega$ )

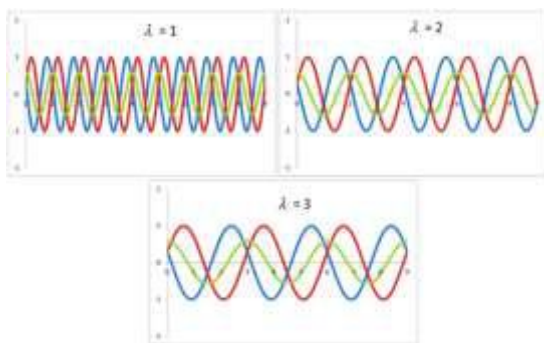


Figure 22. Stationary wave student work at fixed ends varying lambda ( $\lambda$ )

The damped harmonic vibration waveform generated in Microsoft Excel is shown in Figure 23. This waveform is generated from Equation 6 and will stop oscillating over time. To recognize the characteristics of the damped vibration waveform, the conditions for these characteristics must be observed, as explained earlier. One of its main characteristics is the attenuation or decrease in wave amplitude over time. When an oscillating

wave is created, the energy contained in the wave is gradually reduced due to the damping forces acting on the particles carrying the wave. As a result, these waves disappear or weaken over time, depending on the distance traveled. The type of damping can vary depending on the wave transmission medium. Still, generally, a damped vibrational wave is characterized by an amplitude that decreases over time, so the intensity of the wave decreases exponentially.

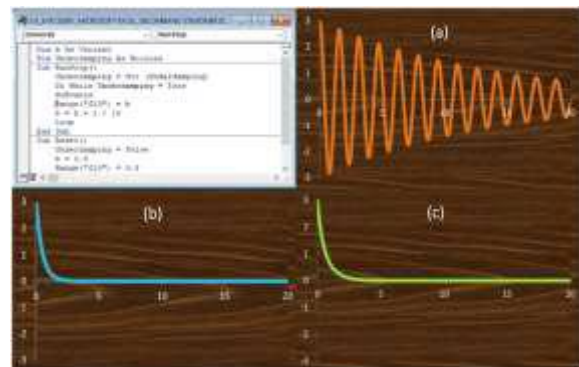
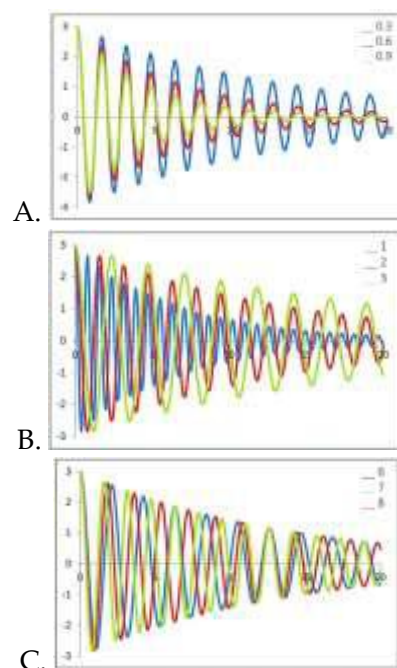


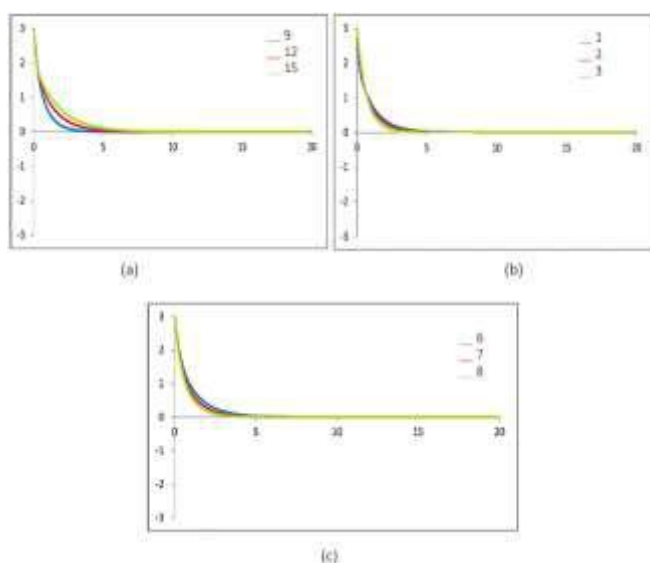
Figure 23. The results of student work on the prototype developed in the form of a Damped Oscillation Waveform: (a) Underdamping; (b) Critical damping; and (c) Overdamping

The damped harmonic vibration waves have the properties of being underdamped by varying the damping constants performed with three treatments, with the wave results as shown in Figure 24 (a,b,c).



**Figure 24.** (a) Underdamping student work results by varying the Damping (b); (b) Underdamping student work results by varying the mass (m); (c). Underdamping students' work by varying the Spring Constant (k)

Furthermore, by varying the mass which was carried out with 3 treatments, the wave results looked like in Figure 24 (b). The damped harmonic vibration wave exhibits the property of overdamping by varying the damping constant (b), performed with three treatments, with the wave results as shown in Figure 25.



**Figure 25.** Overdamped student work results by varying: (a) Damping; (b) Mass; (c) Spring Constant

In addition, the wave results by varying the mass performed with three treatments looked like Figure 25(b). Furthermore, the wave results became visible by varying the spring constant with three treatments (Figure 25c).

## Discussions

Educators are essential in selecting appropriate resources, sorting and collating learning activities, directing student experiments, generating hypotheses with precision, and critically reflecting on the results. The use of simulations also helps students understand physical materials. The interaction between computer simulations, students, available features, and educators causes simulation's effect on science education (Rutten et al., 2012; Sarabando et al., 2014). Therefore, the choice of learning media must be tailored to the

subject matter to be explained. Thus, even when using media, a teacher should be able to monitor the activities of the students when dealing with learning media. To avoid things that have dire consequences and can affect students' concentration. Microsoft Excel is a high-quality software that only requires a little training. However, certain features and skills are necessary to master them, so they may not be immediately accessible to everyone (Barreto, 2015). Excel VBA macros are handy for assigning command buttons to cells whose data we want to change so that they can give a visual impression on the charts created (Alfat et al., 2020; Rohaeti et al., 2019). Microsoft Excel's graphics have a clear and minimalist design (Kraus, 2014). It is possible to create a graph that can be used to simulate data. Microsoft Excel has pre-existing functions that can be utilized for this purpose.

Computer-based simulation is an effective method for facilitating guided practice in many settings that may not be readily accessible to learners inside the traditional educational environment of schools, colleges, or universities. Based on the empirical evidence derived from a recent scholarly investigation, a significant correlation has been observed between the utilization of computer simulations and the students' attainment within the realm of pedagogical and cognitive processes (Alhadlaq, 2023; Guven et al., 2022). Computer simulations can revolutionize learning by expanding access to knowledge, ideas, and complex subjects, facilitating dissemination and communication (Anderson, 2008). This is achieved by offering instructors supplementary possibilities and granting students enhanced prospects for cooperation with their classmates and field specialists. However, the study revealed that while computer simulations are more effective than traditional instructional techniques in teaching science, it has been determined that their utilization in classrooms should be contingent upon the instructors' discretion (Rutten et al., 2012; Smetana & Bell, 2012). According to Amabile et al. (1976) & Jeffery et al. (2022) real research laboratories, as opposed to simulations, can enhance students' understanding of scientific

topics and support their educational experience in a thorough and accessible manner. This technique is expected to improve students' comprehension of the phenomena. Within a simulated computer environment, students can systematically explore hypothetical scenarios, manipulate the temporal scale at which events and actions unfold, and navigate problems within a realistic context, all while maintaining a state of reduced stress. The researchers also emphasized that including simulation courses alone is unlikely to significantly impact students, especially those with lower reasoning abilities who require assistance in effectively comprehending and learning new scientific ideas and concepts that need substantial cognitive skills (Huppert et al., 2002).

The utilization of computational tools has significantly transformed the practice of science, leading to the emergence of novel systems of knowledge that enhance the ease of learning various topics (Arastoopour Irgens et al., 2020). However, before the advent of computers, scientists implemented modifications in representation that yielded notable advantages for those seeking to acquire knowledge. In the study by Gilbert & Zylbersztajn (1985), Galileo's investigation into uniform motion is examined. Specifically, Galileo's approach to elucidating the connections between distance, velocity, and time is analyzed, revealing his reliance on extensive, text-based theorems. The theorems formulated by Galileo transformed into a more simplified representational form, namely  $d = v \times t$ , with the advent of algebra. The algebraic figurative transformation has simplified a complicated notion, making it accessible for secondary school students' comprehension and learning. According to Wilensky & Papert (Wilensky & Papert, 2010), alternative representation refers to a domain restructuring. This restructuring involves modifying the external expression of information within a specific domain, subsequently influencing the internal encoding of knowledge within the individual's mind. The proposition under consideration holds significant merit for the development of educational settings. Similar to how algebra facilitated the comprehension of intricate concepts put forth by Galileo during the

bygone era, contemporary educational reforms, particularly those incorporating computational tools, can enhance students' understanding of complex subject matter, one of them being wave material.

Based on the shown activity, investigated studies consistently demonstrate using several student techniques, including abstraction, algorithm design, coding, and verification (see Figure 1-12). In this particular scenario, students are given a task about the simulation of wave phenomena. Students are instructed to employ computational thinking abilities to answer issues related to wave phenomena. The study of wave phenomena is characterized by its abstract nature and the use of specialized instruments for comprehension. In addition to the wave equation, the field encompasses several mathematical equations, demanding students exercise caution and precision throughout the problem-solving process until its ultimate resolution. Currently, students are restricted to focusing solely on determining the wave deviation equation, such as  $Y = A \sin \omega t$ , without being aware of the pattern that would emerge if the wave were expressed as a sinusoidal or cosine function. Many students experience a sense of being overwhelmed when confronted with this particular topic, particularly when it entails concepts such as angular frequencies and alterations in the temporal phase. The representation of data mutation, particularly the wave equation (difference equation), as seen in equations (1-6), is crucial for facilitating students' comprehension of the underlying concepts of the equation. Particularly when it pertains to principles associated with oscillatory motion. Students need to comprehensively understand the functioning principles of codes, particularly those related to overdamped, damped, and under-damped systems. The modern demands of learning necessitate visualization and procedural techniques, which are inherently intertwined with programming languages. The execution of this content needs to be improved. Computational thinking skills guide students through a systematic process of reasoning, commencing with the stage of abstraction, followed by algorithm design, coding, and verification (Nordby et al., 2022; Polat

et al., 2021). The aim is to methodically organize student comprehension, influencing their reasoning skills and conceptual grasp. The utilization of computational technologies undeniably exerts a substantial influence on the cognitive dimensions of pupils.

The study delved further into elucidating several cognitive tool constructions to augment the pedagogical practices and knowledge acquisition inside science classes. Research by Torres & Madiba (2017) examined incorporating computational thinking skills (CTS) principles and methodologies inside a block-based programming environment while constructing simulation-based models in a science classroom at the middle school level. The students actively participated in experiential learning exercises that fostered their ability to design, alter, and experiment with a force and motion model. Specifically, they simulated wave equation modeling using spreadsheet software, such as Excel, with the incorporation of VBA (Visual Basic for Applications). The students are afterward instructed to comprehend the equations, articulate them in a pattern format, and convert them into coding to achieve a simulation, as seen in Figure (15-27). According to the researchers, students were instructed in various essential computational thinking Skills (CTS) practices, including abstraction and algorithms (Ogegbo & Ramnarain, 2022)

*Excel-VBA is an excellent tool for understanding physics, particularly in the field of wave material. By using Excel-VBA, students can create interactive wave simulations that help explore various wave concepts. They can manipulate parameters such as wavelength, frequency, and amplitude, and observe the direct impact of these changes on waves. This not only improves their understanding of wave material but also encourages creativity and teamwork. By collaborating on complex wave simulations, students gain practical skills in data management, tool design, and problem-solving in physics (Teacher responses related to excel-VBA)*

*Excel-VBA is an exceptional resource for comprehending physics, especially in the sphere of wave material. Through the use of Excel-VBA, pupils*

*can generate interactive wave simulations that facilitate the exploration of diverse wave concepts. They can modify factors like wave wavelength, frequency, and amplitude, and witness the direct influence of these alterations on waves. This not only enhances their understanding of wave material but also stimulates inventiveness and cooperation. By working together on intricate wave simulations, students acquire practical skills in data handling, tool creation, and physics-based problem-solving (Student responses related to excel-VBA)*

They were also taught fundamental computer programming concepts, such as variables, conditionals, and loops. These concepts were imparted through the utilization of the Scratch environment, enabling students to enhance their practical and conceptual comprehension of force and motion. In their study, Sengupta et al. (Sengupta & Kinnebrew, 2013) examine the incorporation of computational thinking (CT) in science classrooms. They elucidate the significance of involving students in fundamental practical aspects of computational representational practices, such as abstractions, pattern generalization, repeated loops, troubleshooting or debugging, and iterative refinement of models. The authors argue that these activities play a pivotal role in fostering the development of students' CT skills and influencing their learning, thinking, and engagement in scientific practices. In aggregate, the data from the examined research suggest that a major factor fundamentally affects the development of pupils. In computer science education, students must be provided with many opportunities to engage with the concepts of abstraction, modeling, and automation. Moreover, ensuring that these educational experiences yield a broader range of learning outcomes tailored to certain topic areas is essential

## Conclusions

Based on the analysis results, using Excel-VBA based on computational thinking skills can provide students with an understanding of basic programming languages integrated Microsoft

Excel. Students can use Excel-VBA despite obstacles related to using Excel with programming languages. Many students are unfamiliar with VBA (visual basic for application), so they need an initial introduction. In addition, applying computational thinking in abstraction, design algorithms, coding, and verification makes it easier for students to compile step-by-step procedures, especially when preparing simulations based on the data provided. This research is preliminary in the dissertation field, so it is still necessary to make it up so that it becomes an interesting source of learning. For further research, obtaining teaching materials or guides is recommended so students can easily use Excel-VBA as a learning instrument

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